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CAMOUFLAGE DISPENSER, HELICOPTER MOUNTED

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AAI Corporation

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New and improved camouflage techniques which will enhance field security are required by Department of Army personnel. This report contains the results of tests, formulations and the operational characteristics of the 73E01-1A dispenser. Various tests (aircraft and static) were conducted at the AAI Corporation, Aberdeen Proving Ground and Bendix Corporation.

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ABSTRACT

New and improved camouflage techniques which will enhance field security are required by Department of Army personnel. This report contains the results of tests, formulations and the operational characteristics of the 73E01-1A dispenser. Various tests (aircraft and static) were conducted at the AAI Corporation, Aberdeen Proving Ground and Bendix Corporation.

FOREWORD

The work described in this report was performed under Task V (LWL 21-C-72) of Contract No. DAAD05-72-C-0108 and Task I (LWL 21-C-72) of Contract No. DAAD05-72-C-0289.

AAI Corporation wishes to acknowledge the cooperation given by Mr. Vincent J. DiPaola, Acting Chief of the Advanced Development Division and the technical assistance granted by Mr. Stephen M. Clancy, Acting Chief of the Applied Chemistry Branch.

TABLE OF CONTENTS

List of Figures

1.0 Scope:

1.0.1 Under USALWL Task 21-C-72, Camouflage Dispenser, Helicopter Mounted, an attempt was made to spray a fast-drying liquid camouflage solution from a helicopter to enhance Army field positions by coating the disturbed installations and blending them into the surrounding terrain.

1.0.2 This report describes the development of a low cost coating solution, testing, and operating characteristics of the Type 73E01-1A Lachrymator Dispenser; which was previously developed for USALWL by the Fluid Power Division, Bendix Corporation under Contract No. DAAD05-68-C-0374.

1.0.3 LWL Task 21-C-72 was funded under two separate task assignment contracts. One-half of the work assignment was assigned as Task No. 5 under Contract DAAD05-72-C-0108 and the second-half was assigned as Task No. 1 of Contract DAAD05-72-C-0289 which has an effective date of 27 April 1972. The reason for this approach was that the older service contract had inadequate funds to accommodate the full scope of work.

2.0 Introduction:

2.0.1 The camouflaging of Army field positions has always been a significant, but difficult operation. This has proved especially true with the increased mobility of Army personnel. The U.S. Army Land Warfare Laboratory has undertaken several novel approaches to the problems of camouflage; these include, urethane foam spraying systems, reflecting surfaces, improved netting and the application of colored liquids sprayed from helicopters.

2.0.2 The objective of this Work Assignment was to determine the feasibility of using the 73E01-1A Lachrymator (CS) Dispenser for aerial dissemination of liquid camouflage solutions.

2.0.3 After conducting the tests described in this report, it was concluded by USALWL, Bendix Corporation and AAI Corporation that using the 73E01-1A Dispensers for the objective purpose, would be of limited success.

2.0.4 In conducting these tests the solutions to the major problems encountered (batteries, pump redesign) were beyond the time frame and moneys available under the task assignment type contract. Consequently a termination order dated 8 August 1972 was effected.

2.1 Description of 73E01-1A Dispenser*:

2.1.1 General: The Bendix type 73E01 dispenser is a selfcontained system which is designed to disseminate a solution of agent CS from a type UH-1 helicopter by means of a high pressure spray. The system consists of a

* Data obtained from Technical Report No. LWL-CR-08C68, dated September 1969.

tank module containing the pump, tank, battery and controls, a fluid delivery line which connects to the discharge valve assembly at the helicopter tail skid, and a cockpit control box. The basic tank module was designed for installation on the outside of the UH-1 helicopter using the external auxiliary fuel nylon and the external stores support assembly mounted on the aft attachment points on the helicopter structure (Figure 1).

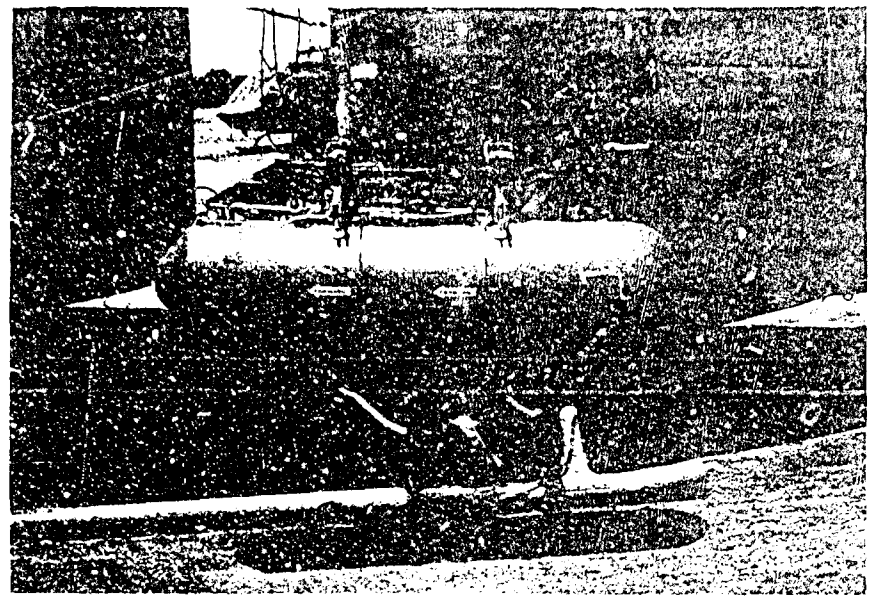
2.1.2 Tank Module: The solution of lachrymator agent is carried in a tank which occupies the greater part of the tank module. A flexible tank bladder encloses the liquid and isolates it from any contact with the atmosphere. A rotary inducer forces the liquid into a positive displacement vane-type pump which is mounted in a bulkhead forming the forward wall of the tank, and is under the control of the helicopter pilot. The direction of rotation of the pump is electrically reversible so that the system can be filled on the ground through a quick-disconnect discharge fitting without need for an external pump. Pressure relief valves limit the pump pressure in both directions.

2.1.3 The pump is driven through a gear train by a shunt-wound totally enclosed electric motor, using energy from a self-contained nickel cadmium battery. This arrangement enables the system to be operated independently of the aircraft electrical system.

2.1.4 A battery charging regulator draws limited power from the aircraft bus only when the bus voltage is high. The battery will retain a nearly full charge after more than a year in storage. The module is equipped with a standard AN-type external power connector which may be used to power the unit during the refilling cycle or for battery charging.

2.1.5 Discharge: The discharge valve assembly consists of a pressure operated anti-dribble valve and a non-clogging type spray nozzle. The assembly is mounted on the tail skid at the aft end of the helicopter to avoid contamination of the air frame. When the pump is turned off, the anti-dribble valve closes off the fluid passage immediately upstream of the nozzle, and the nozzle empties itself by gravity. The fluid line remains full of solution so that flow will re-start immediately when the pump is turned on. The pilot has positive control of the pump which can be turned on and off as required for accurate dissemination of the solution. The quick-disconnect coupling at the tank module can be operated while the lines are full. Self-sealing valves in each half of the coupling close automatically before the coupling is separated and virtually no solution is lost in the operation. The coupling is also arranged so that it will disconnect itself automatically when the tank module is jettisoned from the auxiliary fuel pylon. In this situation the discharge lines and the discharge valve assembly remain attached to the helicopter after the tank module is jettisoned.

2.1.6 Control: A cockpit control box is installed in existing fittings above the helicopter co-pilot's head. This control box, along with two jumper plugs installed in the pilot's console, enables the M-6 armament wiring in the helicopter to be used for control of the dispenser. The dispenser can be fired by depressing the pilot's or co-pilot's firing switch mounted on the cyclic control stick.



73E01-1A DISPENSERS - PORT AND STARBOARD MOUNTING

Figure 1

2.1.7 Specifications:*

Fluid Capacity	25 Gal. + 10% ullage
Tank	Cylindrical tank w/collapsible bladder.
Dissemination Rate	7½ GPM
Pumping Element	Positive displacement, vane type w/ rotary pressure inducer & vapor separator. Reversible for filling.
Discharge Pressure	75 psig
Discharge Nozzle	Single, non-clogging type w/automatic shutoff @ 15-20 psig.
Pump Relief Valve	100 PSID discharge, 8-13 PSID fill (double acting).
Tank Relief Valve	25-45 psig (overboard)
Tank Proof Pressure	24 psig
Tank Overfill Switch	Open @ 5-8 psig
Power Source	Nicad storage battery, 19 cel. 24 V dc, rechargeable
Battery Capacity	5.7 A.H. @ 2 hour rate
Recharging System	Accepts power from aircraft when voltage exceeds 25 V dc; 10 ampere rate tapers to 0 when charged.
External Power	AN 2552-3A receptacle (28.5 V dc) for refilling or battery charging. Directly connected to battery.
Pump Motor	Reversible, shunt wound, totally enclosed
Motor Rating	20 V dc, 9200 rpm, 5.35 lb. in. torque
Weight, Dry	89.0 lbs (pumping module)
Fluid	276.75 lbs (25 gal. CH_2 Cl_2)
Total	365.75 lbs
Nozzle, Hose, Cable, Cockpit Control, Jumpers	12.00 lbs
Grand Total	377.75 lbs
CG, Dry (Pumping Module)	42.9" from aft end
CG, Full (Pumping Module)	30.4" from aft end
Mounting	14" bomb rack (MA4A) (Part of external auxiliary fuel pylon)

* Data obtained from Technical Report No. LWL-CR-08C68, dated September 1969.

3.0 Reconditioning of 73E01-1A Dispensers:

3.0.1 Since the dispensers had been in storage under various climatic conditions for several years - cleansing of the pump assembly and Teflon bladders was of paramount importance. At the recommendation of the project supervisor, the units were first flushed several times with methyl alcohol to remove any residual methylene chloride (CS solvent) and then reflushed with copious amounts of water.

3.0.2 The Nicad batteries were cleaned of corrosion, electrolyte levels checked and demineralized water added to the individual cells, if needed. The standard recharging procedure was followed to bring the batteries up to the nominal 24 volts.

4.0 Selection of Base Emulsion:

4.0.1 The preliminary screening of candidate resin materials was carried out by contacting prime manufacturers of water s luble resins and requesting available technical data and product samples. The following companies were among those canvased:

Asland Chemical Company
Conchemo Incorporated
CPC International
B. F. Goodrich Chemical Company
Rohm and Haas Company
Union Carbide Corporation
Monsanto Company

4.0.2 A matter of major concern in formulating the water based coating was to compound a material that would withstand the high shearing action (1200 rpm) associated with the pump; for this reason Conchemco's Redox-Graft Copolymer Polyvinyl Acetate Emulsion was selected. In addition to its mechanical stability this copolymer is low in cost, stable under alternate freezing and thawing, flexible, has good storage stability, less odor, and an easy acceptance of colorants and absence of water sensitive protective colloid.

4.0.3 To expedite the formulating of camouflage solutions, AAI secured the services of the Columbia Coatings Company, Seat Pleasant, Maryland. In cooperation with C.C.C. the following formula was conceived.

Ingredient	Percent By Weight
Titanium Dioxide	15
Calcium Carbonate	15
Aluminum Silicate	5
Glycols and Non-Ionic Dispersant (Sequestering Agent) (Anionic Dispersant) (Non-Ionic Dispersant) (Anti-Mildew Agent)	2
Redox-Graft Copolymer PVA	19
Water	44

4.0.4 The formula is similar to exterior masonry type paints and should have met the requirements stated in the work assignment. These requirements included:

Sixty to ninety days resistance to weathering.

Compatible with dyes of the Aqua Sperse type.

Can be removed by water washing and a non-corrosive detergent.

Reasonable soil penetration.

Good adhesion to metal and wood structures.

4.0.5 Since the final tests of this camouflage program were to be conducted at Fort Hood, Texas in August 1972, three basic colors were selected to match desert hues. These colors were (1) Sand - No. 2239; (2) Weed Green - No. 2044; and (3) Beach - No. 2303.

5.0 Selection of Spray Nozzle:

5.0.1 Three basic nozzle designs to disseminate the camouflage solution were considered for evaluation, as well as the original Teflon CS nozzle. As shown in Figure 2, they consisted of (1) a flat spray-angled at 49° No. 4050; (2) flat spray - straight No. 5030; (3) a full cone - No. D10-56; and (4) the original Teflon CS nozzle.

5.0.2 Each nozzle design was capable of functioning within the dispenser system operating specifications of disseminating 7.5 GPM and the discharge pressure of 75 psig.

5.0.3 The flat spray nozzle having the 49° angle was selected to be used with the system, because its discharge could be directed aft of the aircraft away from the main rotor blades downwash and thus, provide a controllable pattern (see Figure 3). The flat-spray-straight and full cone nozzles with their small orifices tended to clog, with drying camouflage solution, when operated with intermittent bursts. The original Teflon CS nozzle produced a course spray resulting in a spotted instead of continuous coverage.

6.0 Testing at AAI:

6.0.1 Seven 73F01-1A Chemical Dispensers had been delivered to AAI at the program onset. These units were serial numbered: 3, 5, 9, 11, 12, 19 and 22.

6.0.2 Unit No. 5 had been used in nozzle design selection with the camouflage solution containing 55 percent solids. Although this unit had performed satisfactorily with the high solids content solution, it was concluded by C.C.C., LWL and AAI personnel that greater area coverage and less pump/motor strain could be obtained by reducing the total solids content. Several tests were conducted to determine the optimum percent solids and it was found that solutions below 35 percent had little or no hiding power on freshly disturbed ground, consequently all subsequent tests were conducted using camouflage solutions containing 35 percent solids.

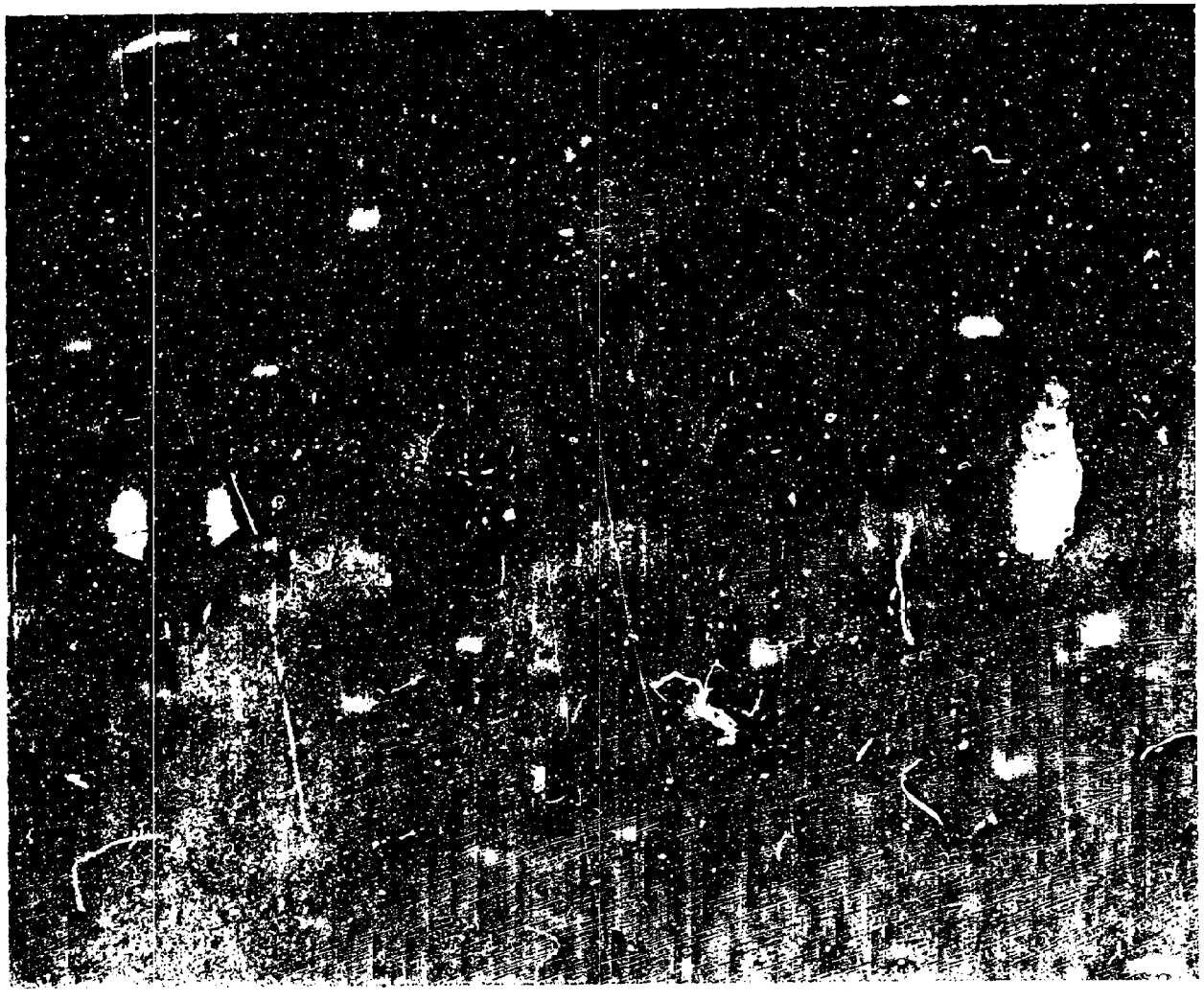
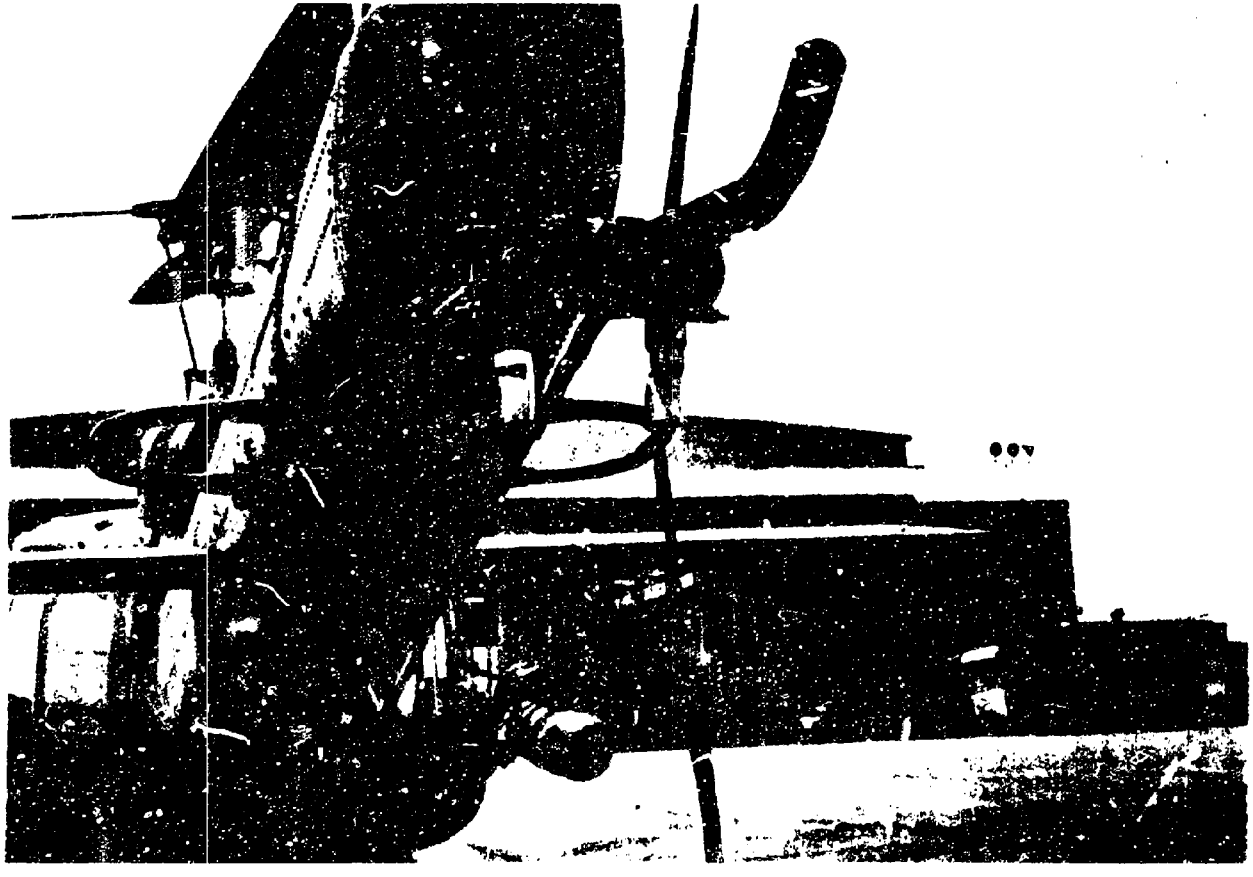


Figure 2 . 1. FLAT SPRAY 49° ANGLE, 3. FULL CONE
2. FLAT SPRAY- STRAIGHT, 4. TEFLON CS NOZZLE



49° ANGLE SPRAY NOZZLE-MOUNTED

Figure 3

6.0.3 The following chart lists the viscosity measurements, weight per gallon of camouflage solutions and materials previously used successfully with the 73E01-1A dispensers.

Viscosity Measurements
(No. 4 Ford Cup)

	Time (Sec.)	Lbs./Gal.
Water (as a reference)	13.0	8.34
Camouflage solutions:		
46% solids	70.0	11.1
35% solids	21.5	10.0
25% solids	15.0	9.1
28% CS (by weight) in methylene chloride	11.5	11.2
Ethylene glycol	15.5	9.2

6.0.4 Each unit was cycled with 25 gallons of water and 25 gallons of the 35 percent solids camouflage solution, and the data tabulated, as in in Figure 4.

Initial Performance Data

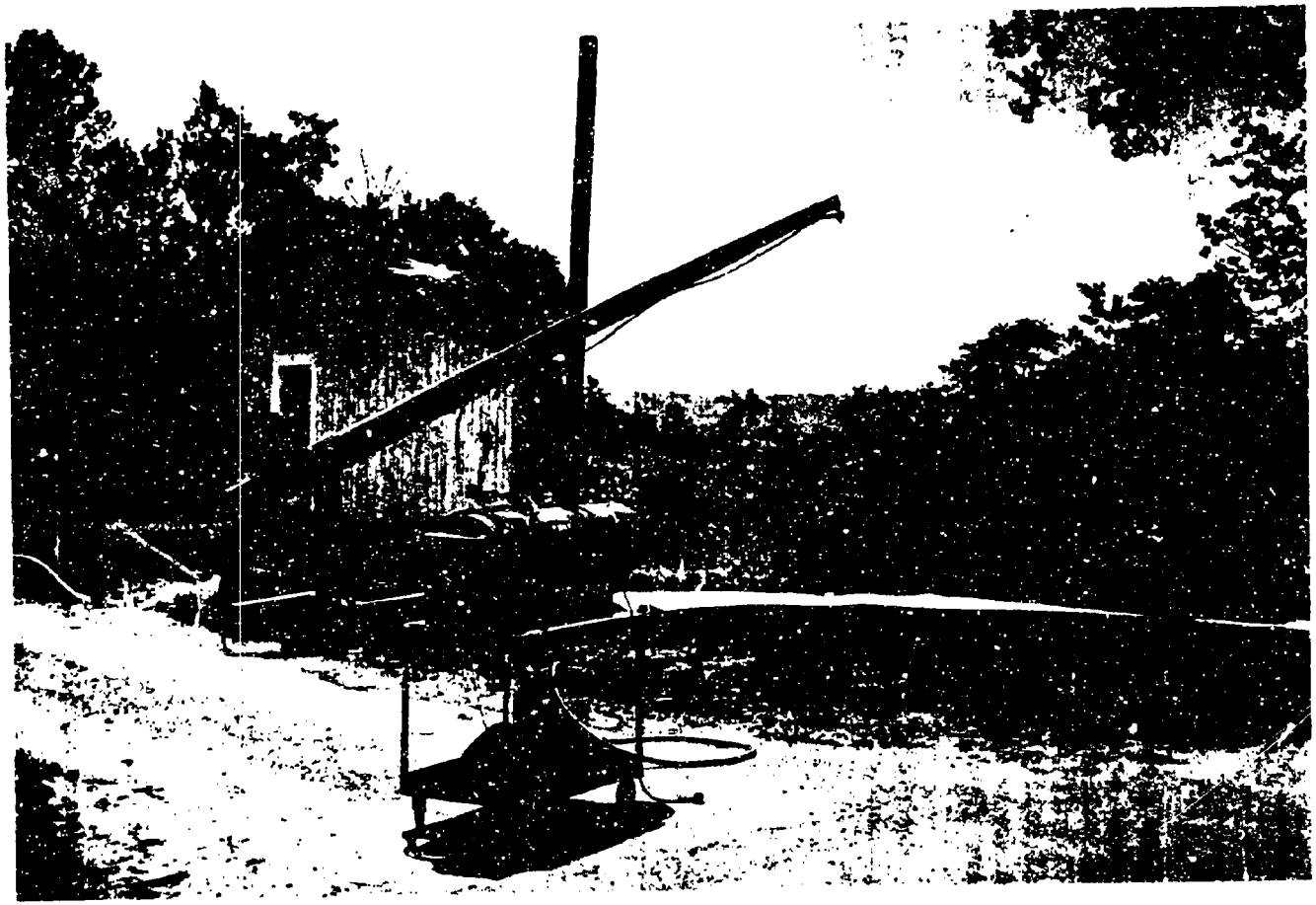
Figure 4

Unit No.	25 Gal. Water Tests Time in Minutes Fill	Expel	25 Gal. Camo. Sol. Tests Time in Minutes Fill	Expel	Comments
11	3.5	2.75	5.0*	3.25	*Fill line contained dry skin.
22	-	-	-	-	Bladder had a leak at the 18-19 gallon mark.
5	3.0	3.0	3.5	4.0	Battery life - 5.0 min.
9	3.0	3.0	4.0	3.0	
19	3.0	3.0	-*	5.0	*Poppet valve cutting in at 15 gallon mark - slow to expel.
12	3.0	3.0	3.0	3.0	Had small oil leak, some pump chatter.
3	-	-	-	-	Bladder had a leak at 10 gallon level.

Units 3 and 22 were found unuseable, because of punctured Teflon bladders.

6.0.5 Figure 5 is a photograph of the test stand used during the initial tests.

*Although the units were filled using 5 gallon pails, great care was taken to avoid air from entering the bladder and was not believed to have caused this malfunction.



TEST STAND

Figure 5

7.0 Flight Tests at APG with 35% Solids Solution: On 8 June 1972 a flight, using Units No. 9 and 11 was conducted at Phillips Army Air Field, Aberdeen Proving Ground, Maryland (See Figures 6, 7 and 8).

7.1 Test Results - Filling Cycle: After installation of the dispenser on a UH-1H helicopter a 28 volt APU was provided to supply the electrical power during fill cycle. Unit No. 11 was filled with 25 gallons of camouflage solution in 4.25 minutes. At 2.0 minutes into the fill cycle of Unit No. 9, the automatic pressure valve became active indicating a full tank. All attempts to correct this problem were negative*; consequently, Unit No. 9 was flown with only 12 gallons of camouflage solution in the tank.

7.2 Test Results - Expelling:

7.2.1 Each unit was activated for a five-second burst on the ground and then test flown in four lanes at the following conditions.

Altitude (feet)	Airspeed (knots)	Cycle Time (seconds)
15-20	45	30
15-20	60	30
35-50	45	30
35-50	60	30

7.2.2 The wind during the test was at a right angle to the aircraft with a speed of 2-3 knots and considered negligible.

7.3 Observations:

7.3.1 The four passes were made and witnessed by three ground observers stationed at 100 yard intervals in each lane.

7.3.2 Unit No. 9 - Expelled solution with a pulse-like action, although its time clock showed 180 seconds of operation, physical examination of this unit revealed approximately 10 gallons of fluid remaining in the tank.

7.3.3 Unit No. 11 - The time clock for this unit indicated a functioning time of 216 seconds, physical examination of the tank revealed 13 gallons of fluid remaining in the tank.

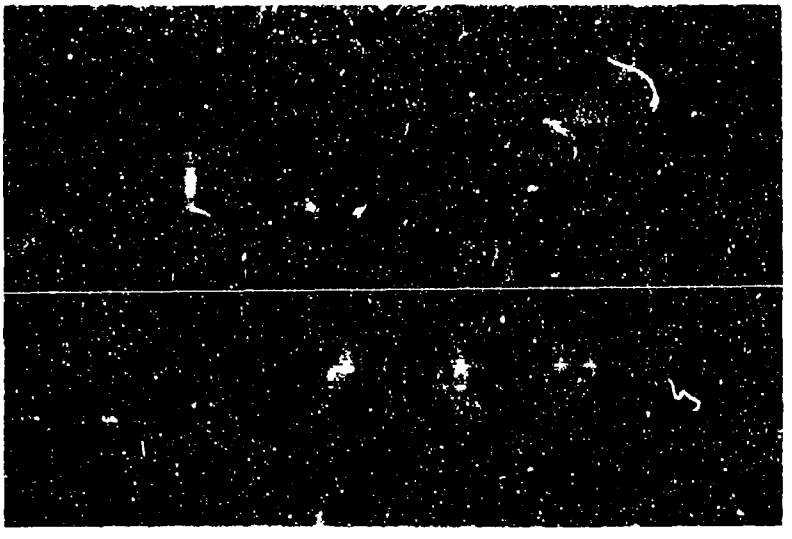
7.3.4 The units were returned to AAI for cleaning and to further investigate the malfunctioning (see Conclusions).

7.3.5 Figure 9 is a photograph of the limited coverage obtained during the second pass (Lane 2).

* Although the units were filled using 5 gallon pails, great care was taken to avoid air from entering the bladder and was not believed to have caused this malfunction.

35% SOLUTION SPRAY TEST

Figure 6

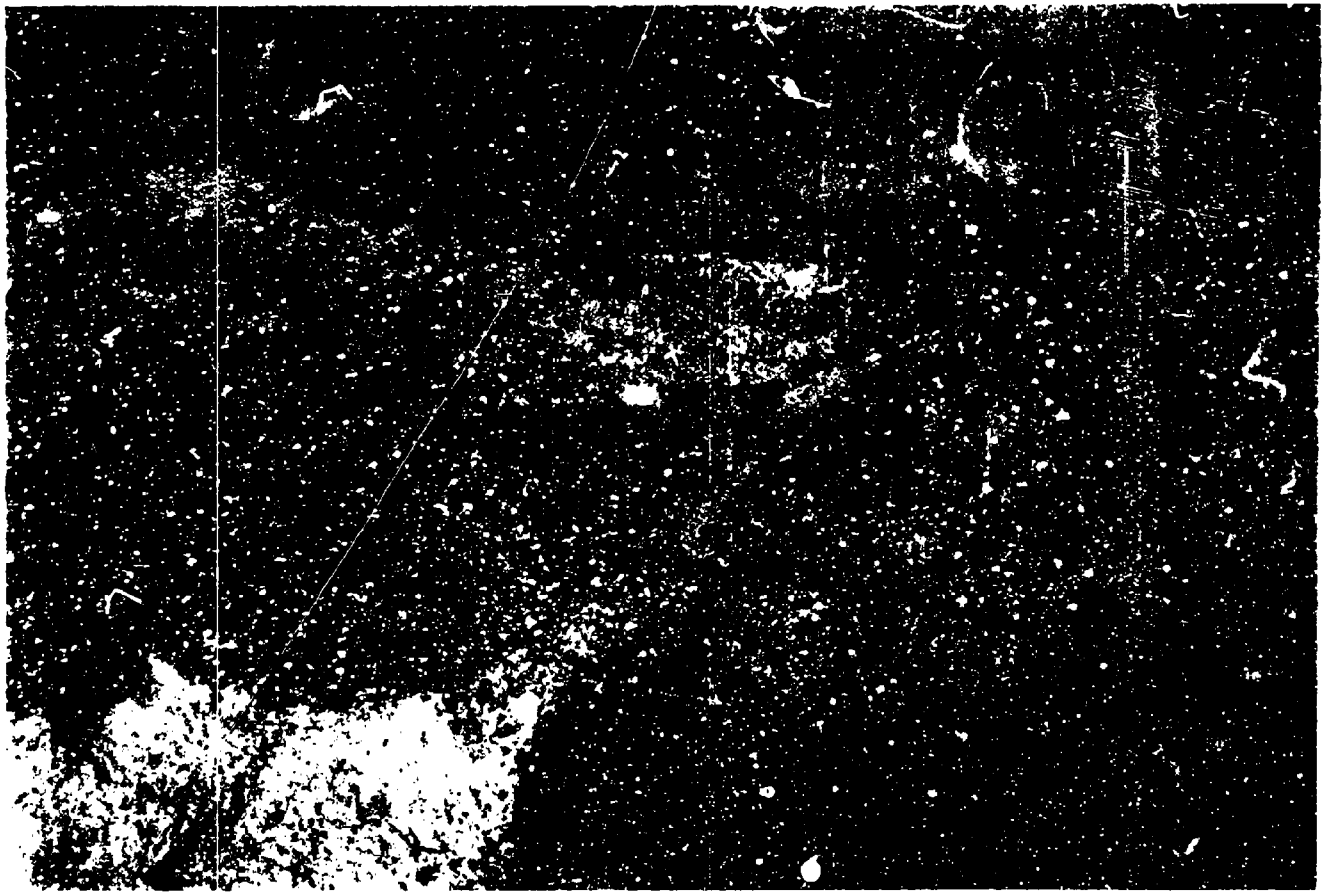


AFFECTED AREA AFTER TEST - DARK LOWER CENTER AREA WAS MASKED

Figure 7

FLIGHT TEST AT ABERDEEN PROVING GROUND

Figure 8



GROUND SPRAY PATTERN DURING FLIGHT TEST

Figure 9

8.0 Retesting at AAI: To determine the cause of low performance at Phillips Army Airfield, APG, Md. tests, the Technical Supervisor directed that AAI instrument the dispenser tanks to monitor the current, voltage and pump speeds during filling and expelling cycles.

8.1 Pressure Data: In order to monitor the line pressure during expelling cycles, a 0-100 psi gauge was installed between the expelling line and shutoff nozzle. Pressure readings (psi) were taken at the start then at 30 second intervals during expulsion cycles and recorded.

8.2 Electrical Data:

8.2.1 At 30 second intervals amperage readings were obtained from a stored trace on a tektronix 564 oscilloscope. Peaks of the current generated curve were counted in milliseconds per centimeter sweep. Pump rpm was calculated using the peaks and corroborated using a General Radio strobe light on a disassembled unit. A Weston 980 analytical meter was used to record voltage directly at battery terminals.

8.2.2 Figures 10 through 17 represent the tabulated data obtained during the retesting phase.

8.2.3 Figure 20 charts the electrical performance of the tested units.

8.2.4 An additional unit designated as X was supplied by LWL during this period. Unit X had previously been used to dispense ethylene glycol in another LWL program.

Unit No.	Cycle Fill	Cycle Expel	Agent Water	Agent Camo.	Cycle Time (sec)	Battery Voltage	Amps	Battery (Remarks)	Nozzle Pressure (psi)	Comments
5	x		x		920	-	-	-	-	Unit filled using, 40 psi on tap water line, without battery power (25 gals.)
5		x	x		0	25.5	-	-	100 (a)	(a) initial pressure taken on triggering-all tests
					30	19.5	55	Recovered	96-98	Total continuous running time = 227 sec.
					60	18.0	58	to 23.0V	92-94	Slight pressure flucturation
					90	18.0	52		88-94	
					120	17.5	55		82-90	
					150	16.5	55		78-84	
					206(b)	12.5	50		-	(b) light indicated unit empty, however, some water remaining required additional 21 sec. to empty.
					227	-	-		-	
5	x			x	0	26.0	-	-	-	Filling 35% solids camouflage solution using battery power
					30	22.25	20		-	
					60	22.0	20		-	
					90	21.5	20		-	
					120	21.5	20	Recovered		
					132		20	to 24.4V		Full 25 gal. @ 132 sec.
						Recharge				
5		x		x	0	27.0	-	-	100	Continuous running time = 186 sec.
					30	19.5	70		100	Motor turning-up 10,000 rpm
					60	19.0	70		100	
					90	18.0	75		94	
					120	17.5	70		94	
					150	16.5	70		88	
					180	14.5	70	Recovered	76	
					186	14.0	"	to 22.5V	-	

Figure 10. Unit No. 5 Performance Data.

Unit No.	Cycle		Agent		Cycle Time (sec)	Battery Voltage	Amps	Battery (Remarks)	Nozzle Pressure (psi)	Comments
	Fill	Expel	Water	Camo.						
9	x		x		497	-	-	-	-	Unit filled using, 40 psi on tap water line, without battery power (25 gallons)
9		x	x		0	24.2	-	-	94	Pressure fluctuations, some chatter.
					30	18.5	60		80-90	
					60	18.2	60		76-88	
					90	17.5	60		72-80	
					120	15.0	68		60-76	
					150	14.75	52		60	
					180	14.25	50	Recovered	58	
					210	11.0	50	to 22.0V	45	
								recharged		
9	x			x	0	26.0	-		-	
					30	22.5	30			
					60	22.0	30			
					90	21.5	30			
					120	21.5	35	Recovered		
					125	21.0	35	to 23.5V		
9		x		x	0	27.0	-		96	Cycle stopped @ 90 sec. heavy chatter and vibrations, motor
					30	20.0	50		94	turning-up only 2400 rpm, all camo. solution removed and flushed
					60	18.5	55		88-90	with water.
					90	17.0	50		20-100	
9	x		-	-	-	-	-	-	-	5 gal. of kerosene pumped in and allowed to set 48-hrs. Unit was cleaned and flushed with water - 25 gallon water test was rerun.
9		x	x		0	26.25	-		88	
					30	20.0	55		88	No chatter or vibrations
					60	18.5	50		66	
					90	17.25	50		64	
					120	16.0	50		60-64	
					150	15.5	45		60	
					180	14.75	45		46	
					210	13.75	40	Recovered	44-46	
					221	12.0	40	to 20.5V		
9	x	-	-	-	-	-	-	-	-	5 gal. kerosene put back-in allowed to set an additional 48 hrs.
9	x		x	-	-	-	-	-	-	Unit filled with 25 gal. of water after kerosene was flushed out
9		x	x		0	25.5	65		92	No chatter or line vibration.
					30	19.5	60		80-92	Some pressure fluctuation.
					60	18.5	55		80-90	
					90	17.5	50		70-80	
					120	16.5	50		64-72	

Figure 11. Unit No. 9 Performance Data.

Unit No	Cycle Fill	Cycle Expel	Agent Water	Agent Camo.	Cycle Time (sec)	Battery Voltage	Amps	Battery (Remark	Nozzle Pressure (psi)	Comments
9		x	x		150	15.0	50		62-72	
					180	14.5	45		6.	
					210	13.0	40	Recovered	58	
					222	10.0	-	to 20.0V		
9	x			x	0	26.5	-		-	*Strong chatter, slight line vibration - only 12 gal. were filled* in the 4.5 min. of operation, solution was pumped back into tank.
					30	22.5	45			
					60	22.0	40			
					90	21.5	40			
					120	20.0	40			
					150	19.75	35			
					180	18.25	35			
					210	18.0	30			
					240	17.75	30	Recovered		
					270	17.0	30	to 21.0V		Test stopped. Unit was filled with water and expelling data taken, using expelling line w/pressure gauge.
9		x	x		0	27.0	-		82-100	Strong chatter, no line vibration
					30	20.0	55		80-94	Some pressure fluctuation.
					60	19.75	55		70-80	
					90	18.0	55		64-72	
					120	17.5	50		60-70	
					150	16.75	5		58-68	
					180	15.5	45		54-60	
					210	14.0	40	Recovered	36	
					2 5	12.0	40	to 20.5V	-	
										Taken to Bendix, Utica, N.Y. for inspection, returned with punctured bladder, battery will not hold charge.

Figure 12. Unit No. 9 Performance Data (Continued).

Unit No.	Cycle Fill	Cycle Expel	Agent Water	Agent Camo.	Cycle Time (sec)	Battery Voltage	Amps	Battery (Remarks)	Nozzle Pressure (psi)	Comments
11	x		x		504	-	-	-	-	Unit filled using, 40 psi on tap water line, without battery power (25 gals.)
11		x	x		0	24.0	-	-	90	Continuous running time = 181 sec
					30	19.5	55		84	
					60	19.0	55		82	
					90	18.5	55		80	
					120	17.8	52		78	
					150	17.0	52	Recovered	70	
					181	15.0	50	to 22.0V recharge	30	
11	x			x	0	26.5	-	-	-	Filling 35% solids, camouflage solution, using battery power.
					30	23.0	30		-	
					60	22.5	35		-	
					90	22.2	35		-	
					120	21.9	35	Recovered	-	
					132	-	-	to 24.2V recharge	-	
11		x		x	0	26.5	-		100	Continuous running time = 172 sec.
					30	20.2	65		96	Motor turning - up 10200 rpm
					60	19.4	60		94	
					90	18.5	60		90	
					120	17.5	60		84	
					150	14.0	55	Recovered	68	
					172			to 23.5V		
11	x			x	0	26.0	-			New batch of 35% solids camo. solution.
					30	23.0	40			
					60	22.5	40			
					90	22.25	40			
					120	21.75	40			
					150	21.5	35			
					180	20.75	35	Recovered		
					196	19.75	35	to 21.0V		
11		x		x	0	26.25	-		100	
					30	20.0	75		96	Expelled 16-18 gal. in 120 sec.
					60	19.0	75	Battery	90-98	
					90	18.25	75	Failing	92	
					120	16.75	70		88	
						Required a Recharge				
					(0)	26.0	-		100	Leaks @ expelling line fitting.
					(30)150	20 25	75		96	
					(60)180	19.5	75		80-90	
					192	18.75	75		-	

Figure 13. Unit No. 11 Performance Data.

Unit No.	Cycle Fill	Cycle Expel	Agent Water	Agent Camo.	Cycle Time (sec)	Battery Voltage	Amps	Battery (remarks)	Nozzle Pressure (psi)	Comments
12	x		x		574	-	-	-	-	Unit filled using 40 psi on top water line, battery power used to move impellor away from opening to assist fill heavy chatter encountered.
12		x	x		0	24.5	-		98	
					30	19.5	60		94	
					60	18.5	60		88-90	Small amount of pump chatter
					90	18.0	65		82-88	
					120	17.5	52		76-80	
					150	16.75	50		76-78	
					180	15.00	50	Recovered	70	
					210	-	48	to 21.5V recharge		
12	x			x	0	25.0	-		-	
					10	22.5	35			Pump ran smooth
					60	22.0	35			
					90	22.0	35			
					120	22.0	35	Recovered		
					132	22.0	35	to 24.0V		
12		x		x	0	26.0	-		100+	Heavy line vibration and pressure fluctuation @ 45 sec. into cycle
					30	19.5	70		100+	Motor turning-up only 2400 rpm
					45	19.5	70		0-100+	Scope pulse readings indicate motor turning-up 2400 rpm - removed expelling line and emptied, using fill line, refill unit with water.
12		x	x		-	26.0			0-100	Heavy vibrations and chatter, motor again turning-up only 2400 rpm - large fill hose used to drain liquid.
12	x									All water removed from unit and 5 gal. of kerosene pumped in an attempt to lubricate pump system allowed to set 48 hrs.
12	x		x							Unit filled with 25 gal. of water after kerosene was flushed out.
12		x	x		0	26.0			100	No chatter or line vibrations.
					30	20.0	65		88-94	Some pressure fluctuations.
					60	18.0	65		80-90	
					90	18.0	60		78-82	
					120	17.5	60		70-80	
					150	17.0	60		72	
					180	16.5	55	Recovered	60	
					201	14.0	45	to 21.0V	56	
										Unit flushed with methyl alcohol to remove gum residue from kerosine bath.
										Battery deep cycled.

Figure 14. Unit No. 12 Performance Data.

Unit No.	Cycle: Fill	Cycle: Expel	Agent: Water	Agent: Camo.	Cycle Time (sec)	Battery Voltage	Amps	Battery (Remarks)	Nozzle Pressure (psi)	Comments
19	x		x		505	-	-	-	-	Unit filled using, 40 psi on tap water line, without battery power (25 gals.) battery has corrosion.
19		x	x		0	24.5	-			
					30	19.7	55		90-92	Pressure fluctuation, pump chatter resulted in expelling line vibration
					60	19.25	55		90-96	
					90	18.75	55		86-94	
					120	18.25	55		82-92	
					150	17.5	55		76-86	
					180	16.5	55	Recovered	72-82	
					[illegible]	12.0	50	to 21.5V	68-78	
19	x			x	0	25.0	-			Filling 35% solids camouflage solution using battery power
					30	22.0	35			Slight chatter in pump
					60	21.8	35			
					90	21.5	35			
					97	-	-			23 gal. fill @ 94 sec.
19		x		x	0	26.5	-		100	
					30	21.0	45		50-70	Pump chatter started @ 30 sec. mark, large pressure fluctuations
					60	21.00	45		40-60	
					90	20.5	35		20-40	
					120	21.5	35			
					150	21.5	30	Recovered	-	
					180	-	-	to 23.0V		
								recharge		Unit was filled with water, allowed to set overnight before expelling
19		x	x		0	26.0	-		80-100	
					30	25.25	65		80-100	Pump chatter through-out cycle, large pressure fluctuation
					60	20.00	65		80-100	
					90	19.5	65		76-96	Motor turning-up only 5000 rpm
					120	18.5	65		76-96	
					150	18.5	60	Recovered	70-90	
					180	18.0	50	to 23.0V	64-84	
19	x									5 gal. of kerosene pumped in allowed to set 48 hours.
19	x		x							Unit filled with 25 gal. of water after kerosene was flushed out
19		x	x		0	26.5	-		80-100	Slight chatter, 20 psi line fluctuation but no line vibration
					30	20.5	55		80-100	
					60	19.0	55		80-100	
					90	18.5	55		80-100	
					120	17.25	50		78-90	
					150	16.5	45	Recovered	78-90	
					178	15.0	40	to 21.0V	70-80	

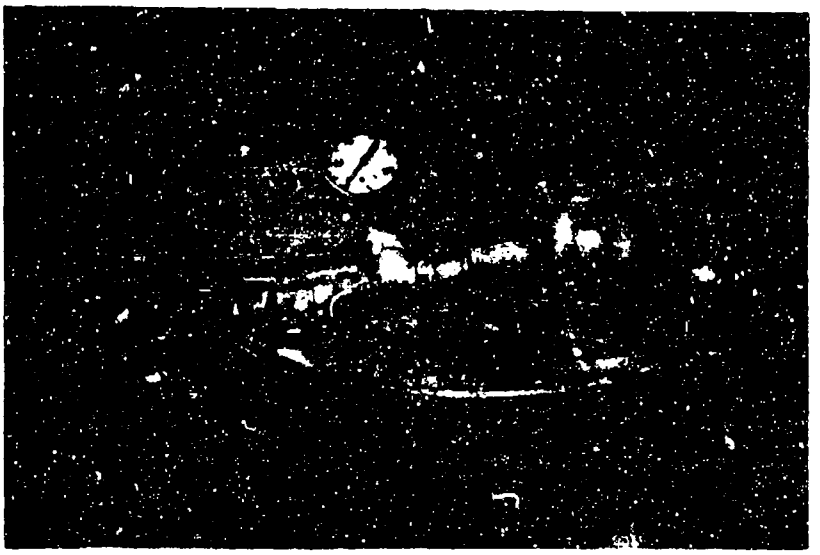
Figure 15. Unit No. 19 Performance Data.

Unit No.	Cycle: Fill	Cycle: Expel	Agent: Water	Agent: Cmpd.	Cycle Time (sec)	Battery Voltage	Amps	Battery (Remarks)	Nozzle Pressure (psi)	Comments
19	x			x	0	26.5	-			After 4.0 min. of filling, dispenser contained only 5.0 gal. cmpd. sol. pumped back into fill drum
					30	23.25	35			
					60	22.5	35			
					90	22.25	35			
					120	22.0	35			
					150	22.0	35			
					180	22.0	35			
					210	21.75	30			
					240	21.5	30			
19	x		x		Not Taken					Unit filled w/25 gal. water, failed to expel some until line was primed.
										Flushed with methyl alcohol to remove gum residue caused by kerosene rinse.
										Battery deep-cycled.
										Filled with 25 gal. water from line
19		x	x		0	24.75	-		92	
					30	19.25	55		86-92	Loud chatter first 125 sec., battery recovered to 23.0 V
					60	19.0	55		86-92	No line vibration
					90	18.5	55		84-90	
					120	18.0	50		82-86	
					150	17.25	50		74-78	
					180	13.75	40	Case was	56-60	
					210	10.0	40	hot	44	
					218	7.5	-		10	

Figure 16. Unit No. 19 Performance Data (Continued).

Unit No.	Cycle		Agent		Cycle Time (sec)	Battery Voltage	Amps	Battery (Remarks)	Nozzle Pressure (psi)	Comments
	Fill	Expel	Water	Gumo.						
X	x		x		694	-	-	-	-	Unit filled using 40 psi on tap water line without battery power (25 gals) unit previously held ethylene glycol.
X		x	x		0	25.75	-	-	100	
					30	19.5	60		92	Continuous running time 210 sec.
					60	19.0	60		82-90	
					90	18.5	60		80-86	
					120	18.2	60		76-82	
					150	17.5	60		70-78	
					180	16.5	58	Recovered	68-70	
					210	15.0	55	to 22.5V recharge	60-74	
X	x			x	0	26.0	-			
					30	24.5	30			
					60	22.0	30			
					90	21.5	30			
					120	21.0	30	Recovered		
					140	21.0	30	to 24.0V recharge		
X		x		x	0	25.5	-		100	Continuous running time 200 sec.
					30	20.0	70		94	Motor turning-up 10,000 rpm
					60	20.0	80		88-92	
					90	18.5	80		86-90	
					120	18.0	80		82-86	
					150	17.5	80		76-82	
					180	16.0	70	Recovered	72-74	
					200	16.0	70	to 23.0V	66-70	

Figure 17. Unit No. X Performance Data.



EXPELLING LINE PRESSURE GAUGE

Figure 18

ELECTRICAL PERFORMANCE MONITORING

Figure 19

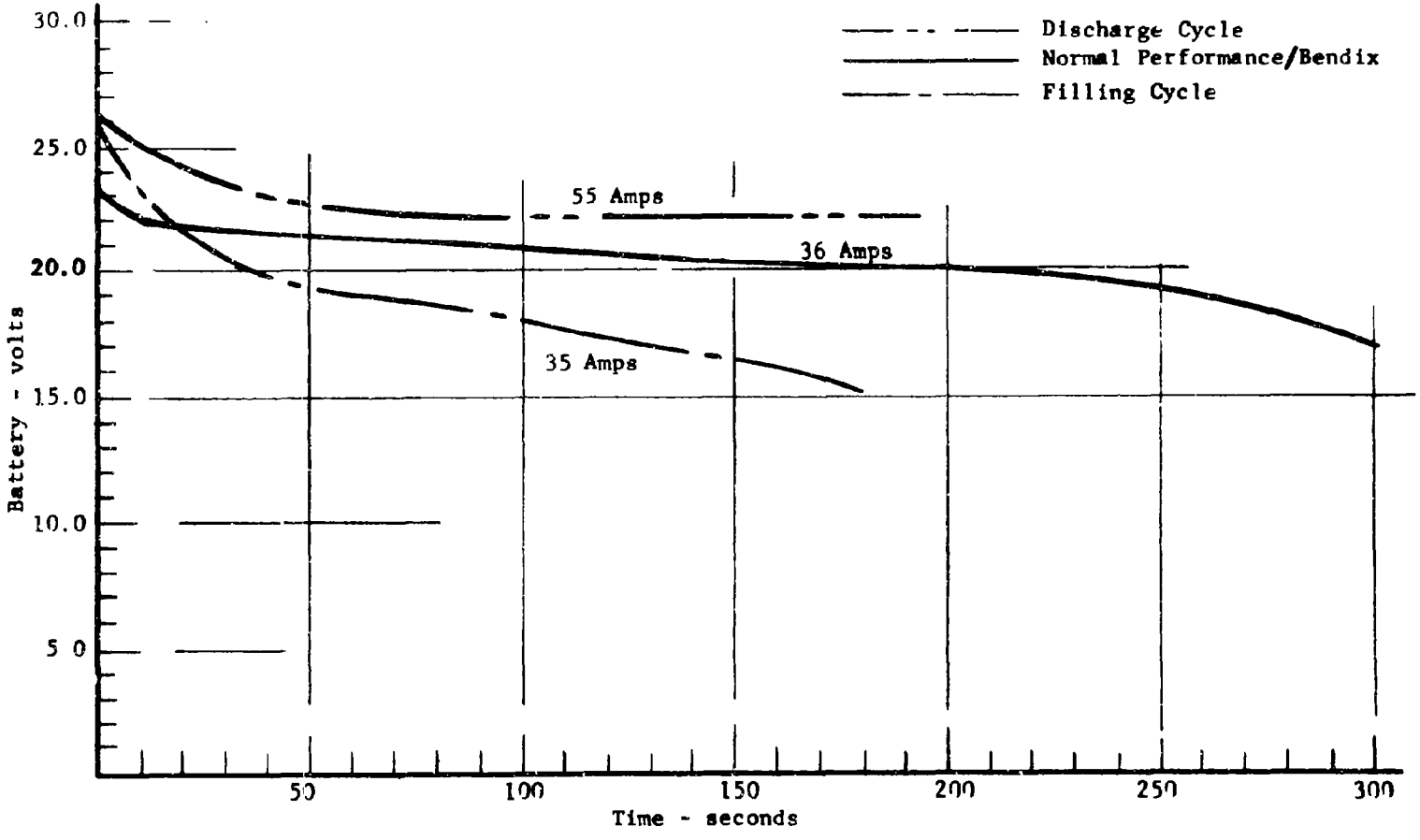


Figure 20. Electrical Performance Chart.

9.0 Examination by Bendix Corporation:

9.0.1 To determine the cause of low reliability in the units the LWL task supervisor and AAI engineering representative contacted the Bendix Corporation and solicited their services, for purpose of performing a diagnostic examination of one unit having a history of low performance.

9.0.2 On 12 July 1972 Unit No. 9 was taken to the Fluid Power Division of the Bendix Corporation at Utica, New York (the original manufacturer) for evaluation.

9.0.3 The unit was systematically disassembled and each part was examined for severe wear corrosion and/or misalignment.

9.1 Results:

9.1.1 The bladder and pump assembly did contain some paint residue from previous tests, one pump vane was dragging against the face plate and the vane pump rotor had adhered to the shaft. There was no trace of corrosion within the dispenser.

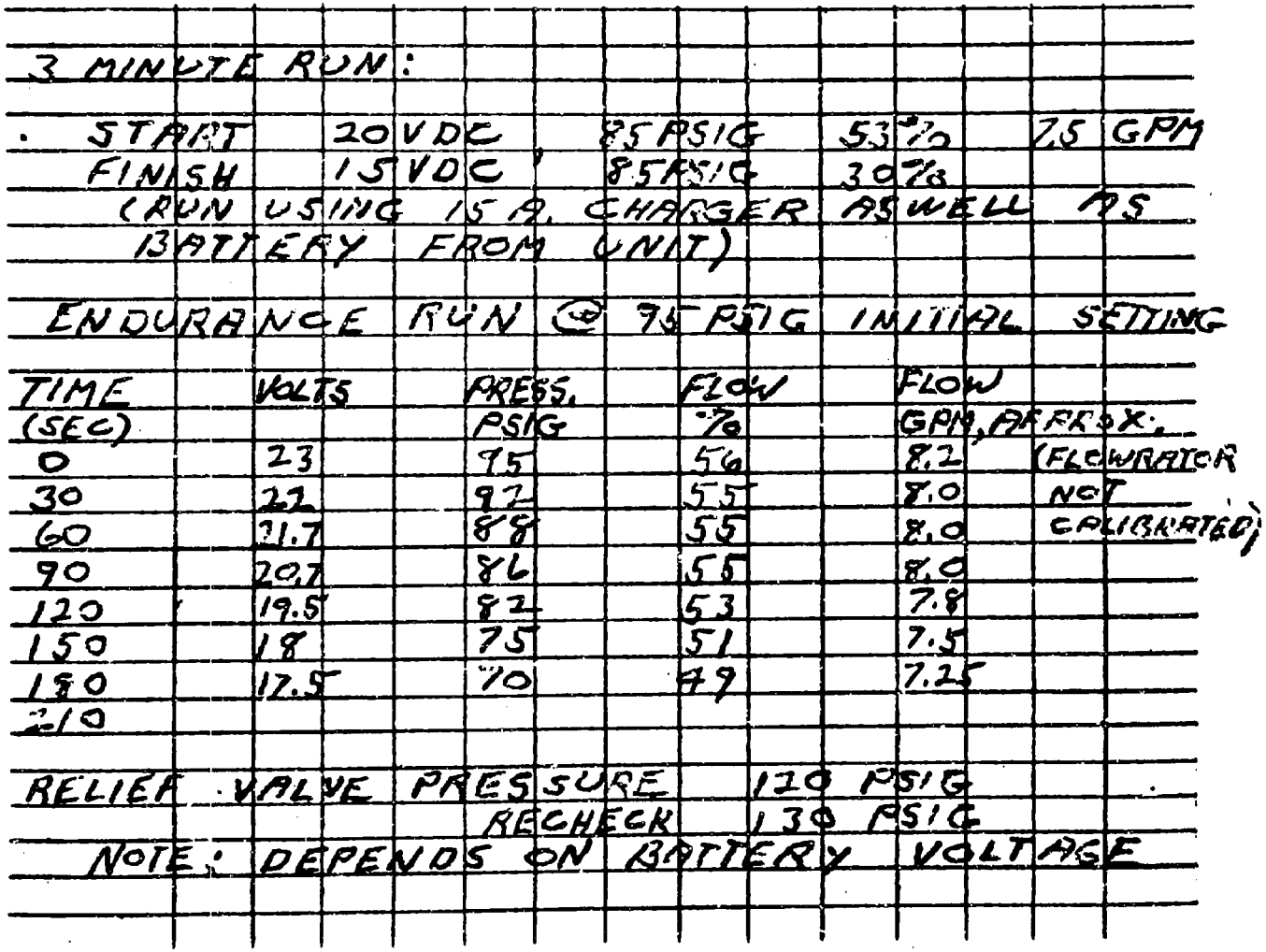
9.1.2 It was the considered opinion of the witnesses that although the above findings would contribute to low performance they could not be solely responsible for the units erratic behavior in early tests.

9.2 Testing: After a thorough cleaning, the unit was reassembled filled with water and readied for testing. An attempt was made to operate the unit as in previous tests on its battery power; however, after one minute of operation, the battery voltage dropped to 13 volts. It was then necessary to use an external power supply at a regulated 20 volts and 15 amps. The unit was then discharged of water in normal time without incident and the data recorded. Figure 21 is a record of the data obtained, and the complete test of the Bendix examination is listed in the Appendix.

9.3 Conclusions:

9.3.1 The poor condition of the battery on Unit No. 9 may have caused the low performance experienced in previous tests at AAI and APG. This battery is a standard aircraft type of nickel cadminum, nominally rated at 24 volts and should provide 7 minutes at a discharge rate of 36 amperes.

9.3.2 Figure 22 was provided by the Bendix Corporation and represents their data, obtained in testing the 73E01-1A pump motor during the dispenser design study.



3 MINUTE RUN:

START	20 VDC	85 PSIG	53%	7.5 GPM
FINISH	15 VDC	85 PSIG	30%	

(RUN USING 15 A. CHARGER AS WELL AS BATTERY FROM UNIT)

ENDURANCE RUN @ 95 PSIG INITIAL SETTING

TIME (SEC)	VOLTS	PRESS. PSIG	FLOW %	FLOW GPM, APPROX.	
0	23	95	56	8.2	(FLOWRATOR
30	22	97	55	8.0	NOT
60	21.7	88	55	8.0	CALIBRATED)
90	20.7	86	55	8.0	
120	19.5	82	53	7.8	
150	18	75	51	7.5	
180	17.5	70	49	7.25	
210					

RELIEF VALVE PRESSURE 120 PSIG

RECHECK 130 PSIG

NOTE: DEPENDS ON BATTERY VOLTAGE

Figure 21. Unit No. 9 - Bendix - Endurance Run.

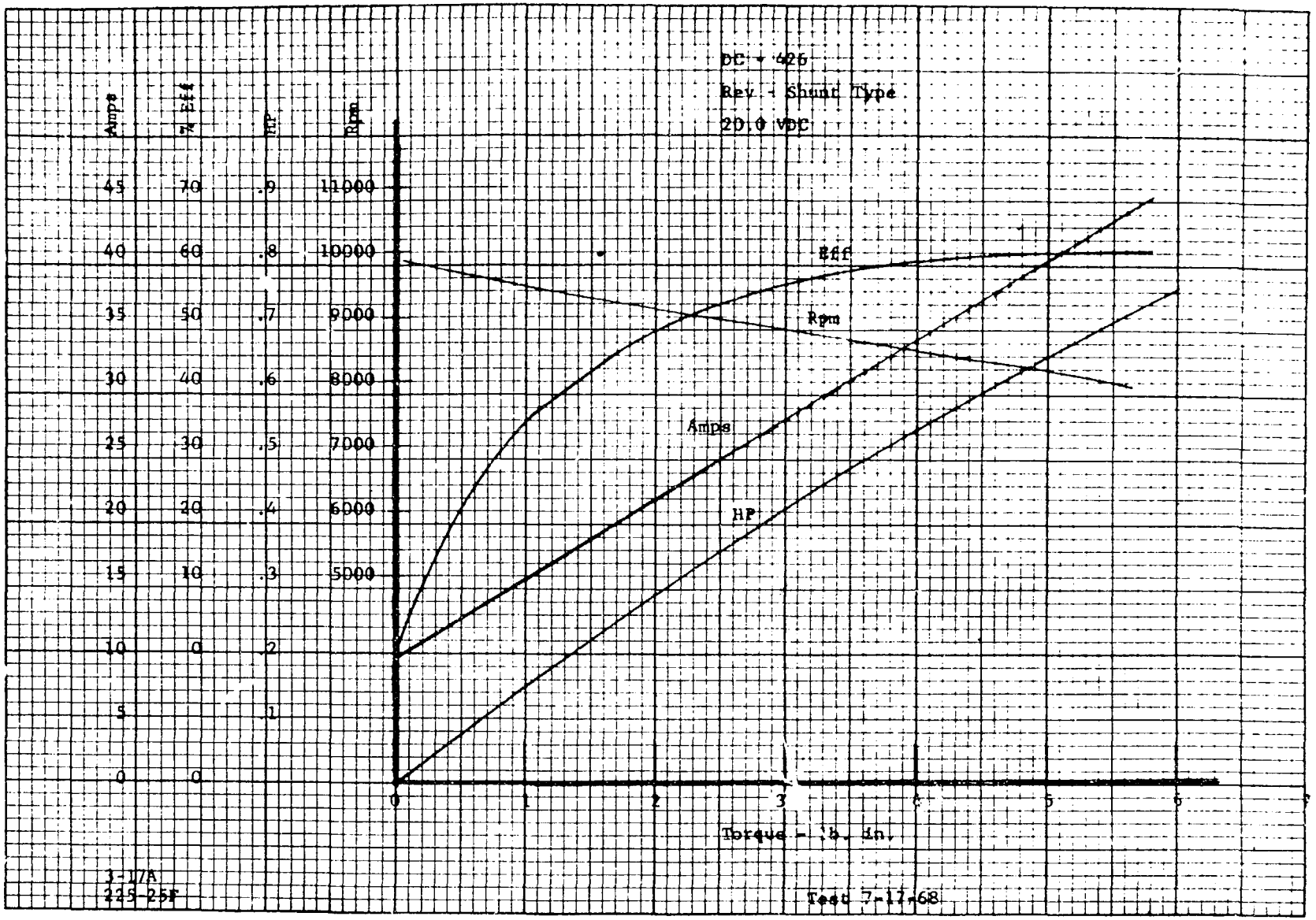


Figure 22. Original Pump Motor Performance Data.

10.0 Battery Deep-Cycling:

10.0.1 At the recommendation of Bendix Corporation the batteries from units 19, 12, 9 and 22 were deep-cycled.

10.0.2 The deep-cycle procedure consists of a continued discharge of the battery until a "flat" state is reached then recharging at a fixed rate.

10.0.3 The four batteries listed above had 10 ohm resistors placed across the positive and negative terminals, each of its 19 cells was monitored until 0.6 volts was reached. At this point the individual cells were shorted with metal straps. During a constant voltage discharge it is impossible to short out all cells, since the current decreases as the voltage decreases. Therefore, when 75 percent of the cells were shorted with metal straps a 1.0 ohm resistor of 1 watt was placed across the remaining cell terminals.

10.0.4 The batteries were maintained in a shorted state for at least 3 hours, then recharged at a fixed rate of 1.2 amps for 7 hours.

10.0.5 Voltage readings after recharging were:

Unit No.	Total Voltage	Cell Range (v)
19	25.6	1.34 - 1.36
12	25.1	1.31 - 1.32
9	25.5	1.31 - 1.32
22	25.75	1.34 - 1.36

10.0.6 Although the deep-cycling was carried out in the prescribed manner, battery No. 9 would not hold the full charge more than one hour and its total voltage would drop from 25 volts to 13 volts if held under system load for 30 seconds.

10.0.7 Expelling tests with dispenser No. 19 after deep-cycling showed a more rapid drop in voltage while operating. A comparison performance chart is shown in Figure 23. Additional information can be found in Sections 8 and 9. Figure 24 shows the front view of the 73E01-1A battery with individual cells.

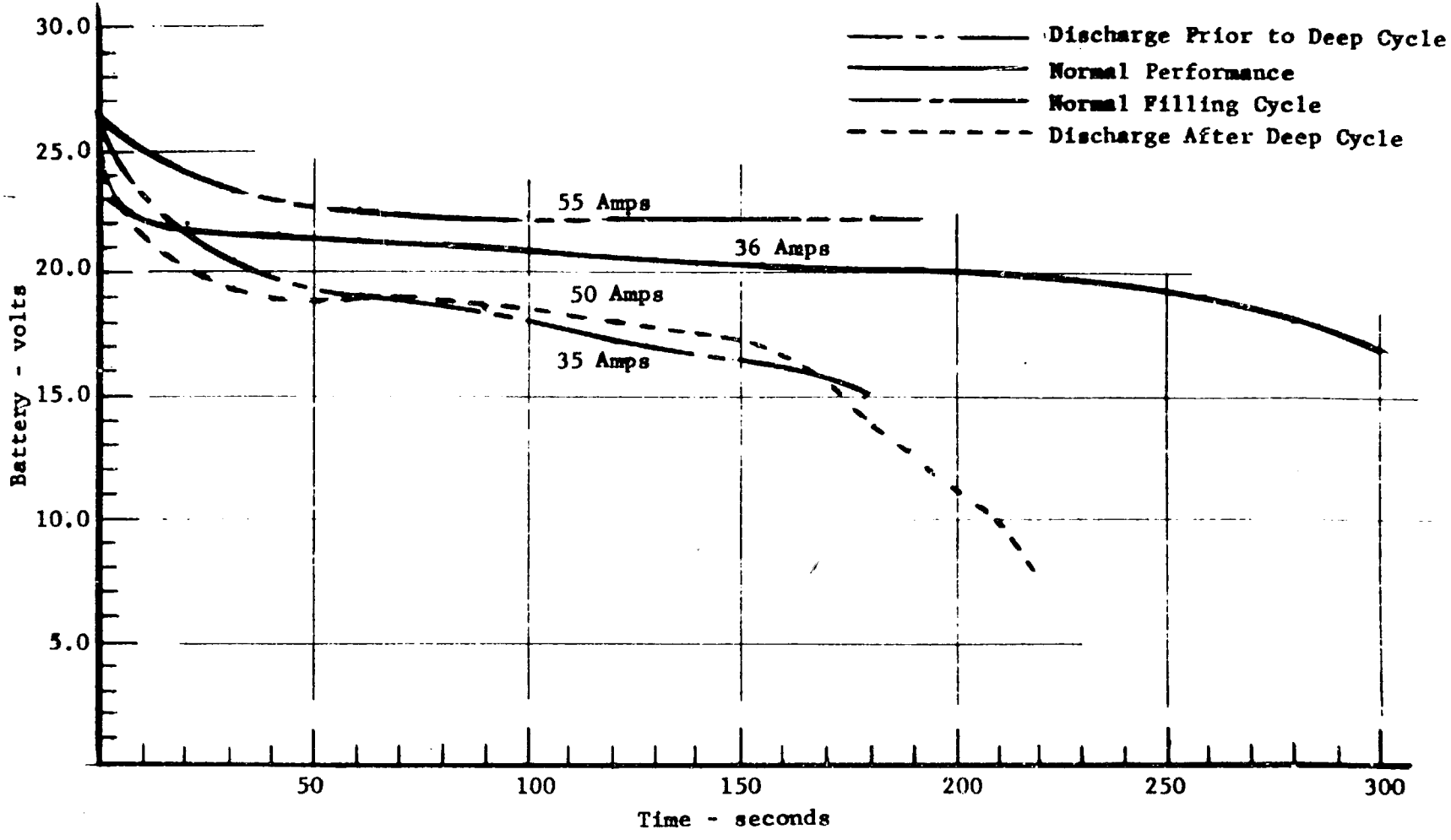
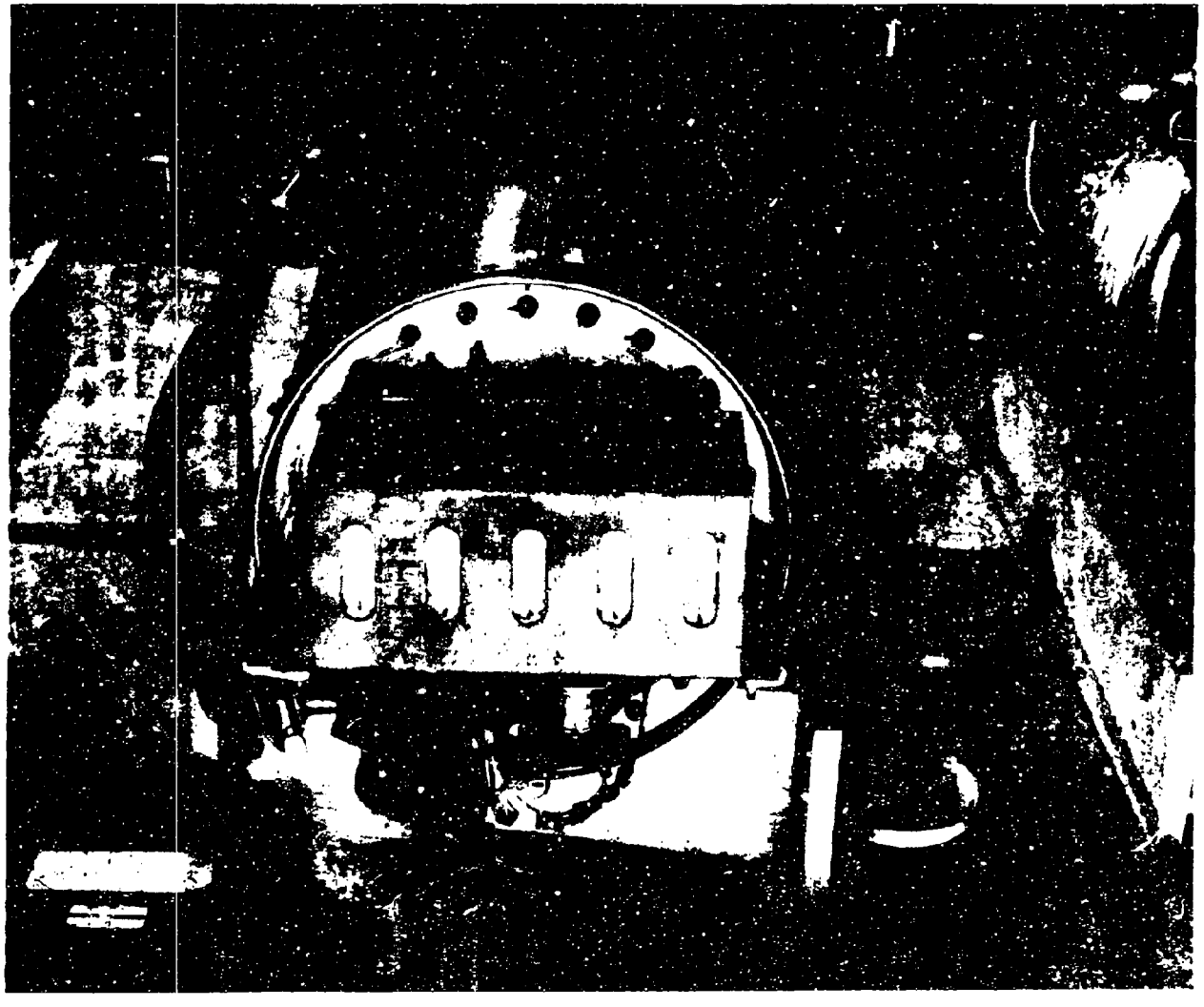


Figure 23. Battery Discharge Performance.



FRONT VIEW OF 73E01-1A BATTERY
SHOWING 19 INDIVIDUAL CELLS

Figure 24

11.0 Results and Conclusions: After testing the 73E01-1A CS Dispensers for purpose of determining their feasibility as a means of dispensing liquid camouflage solutions - it may be concluded that:

11.0.1 Only three units of the eight tested, operated with any degree of reliability.

11.0.2 The chatter and line vibration problems encountered were probably caused by low pump/motor RPM's.

11.0.3 Unit performance appears to have degraded in proportion to operating time.

11.0.4 Poor battery operating power was probably a result of long storage time in an S.E.A. environment.

11.0.5 The dispensing aircraft would have been required to spray from a hovering position at extremely low altitudes and any dusting of unstable soil would have generated visual problems.

11.0.6 It is estimated that one aircraft sortie would only be capable of affecting an area 100 feet by 100 feet, based on the assumed area coverage of 200 square feet per gallon of camouflage solution.

11.0.7 Pump capacity would not be sufficient for operational use.

11.0.8 Design changes necessary for efficient performance were outside the scope and funding of the task.

12.0 Recommendations:

12.0.1 If the concept of aerial dissemination using the 73E01-1A Dispenser's is to be pursued by USALWL, two component changes should be considered:

12.0.1.1 New batteries with slightly higher ratings should be acquired.

12.0.1.2 The present vane type pump should be changed to a type more suited for handling liquids with a relatively high solids content.

12.0.2 It is further recommended that USALWL consider the feasibility of using the trailer mounted spray system developed under Task 09-C-69 of Contract No. DAAD05-68-C-0389 as means of spraying camouflage solutions.

12.0.3 If the trailer mounted system were used for the purpose of spraying liquid camouflage the following considerations could be possible.

12.0.3.1 The selection of materials to be sprayed would be greater.

12.0.3.2 Color change at the site could be made.

12.0.3.3 Loose soil could be stabilized.

12.0.3.4 Larger quantities of camouflage solution could be handled with a 3/4-ton truck-trailer combination.

12.0.3.5 The ground spraying personnel would have better control of the spray equipment and areas to be camouflaged.

Appendix

Bendix Report

Bendix

Fluid Power Division

7/72-13

AAI
P.O. Box 6767
Towson
Maryland 21204

18 July 1972

Attention: Mr. E. R. Evans
Dept. 191

Dear Sir:

The following is a summary of findings in the disassembly inspection of Bendix Type 73E01-1A Chemical Dispenser, Serial No. 9. The disassembly, reassembly and test were performed at the Bendix Utica plant on June 12 and 13, 1972, under AAI purchase order No. 400904. The dispenser had been used to pump water, ethylene glycol, kerosene, and camouflage paint.

Disassembly

The bladder and pump contained solid residue from the paint in globs up to 1/8 inch thick. Some of the residue was hard, but hardening could have occurred during disassembly upon exposure to the air. In addition, the pump contained some gummy solids. All pump ports and passages were open. The pump vanes were dragging in the rotor slots but were not bonded in place. The vane pump rotor was bonded to the shaft by the paint solids and had to be removed by impact.

There was no evidence of corrosion anywhere in the dispenser, nor of excessive wear or other abnormal conditions except as described above.

Reassembly

The greatest part of the paint solids was removed from the bladder and pump by washing with acetone and water. It was necessary to turn the bladder inside out for cleaning. The pump vanes and rotor were cleaned and lightly polished on the surfaces which had been sticking.

The pump motor and gearbox were checked for free-run speed at 20 VDC. The measured speed was 11,300 RPM which is the nominal design value.

The pump was reassembled using the original seals and was tested with water. The test data is shown on the attached sheet. The pump performed well with no evidence of cavitation or chatter.

The nickel-cadmium storage battery from the dispenser was re-charged and was used to operate the pump for this test, but it proved inadequate for the job. The battery apparently was in need of deep-cycle reconditioning service to equalize the state of charge of the individual cells. The tests were completed with a 15-ampere power supply connected across the battery terminals.

The dispenser was reassembled and was filled with water, displacing the air by gravity. The original seals were reused, and the safety wire was not replaced. There was some external leakage which appeared to be coming around the O-ring at the bladder flange.

Test

An attempt was made to operate the system by battery but the performance was poor. The battery voltage dropped to 13 volts after 60 seconds (should be above 20 volts for 180 seconds). An external

power supply was connected for the remainder of the test, regulated at 20 volts. The discharge cycle was then completed, and the dispenser was refilled with water, by means of the internal pump, until the bladder was fully extended. The system was then discharged.

The test results are shown on the attached data sheet.

The performance of the dispenser, with the external power supply, was good and there was no evidence of chatter, cavitation or other distress. The discharge indicator light was not working.

Conclusions

The general condition of the dispenser was very good, with no evidence of deterioration or corrosion.

The pump vanes were dragging, and the vane pump rotor was bonded to its shaft because of solid paint residue. Either condition could have resulted in poor pump performance.

The state of charge of the battery was poor, apparently due to cell imbalance. This was probably caused by extended storage in a hot environment (Viet Nam). The battery can likely be restored to full capacity by deep-cycle charging.

Very truly yours,

W E Coman

W. E. Coman/sl
Senior Engineer

Attach

cc: U.S. Army Limited War Lab.
Aberdeen, Md.
Attn: Mr. S.M. Clancy/CRD LWL-7A

Bendix Fluid Power Division

E.C. NO. _____
E.X.T.I. _____
Date of Test 7-13-72
By G KELLY

Title 73E01-1A CHEM. DISPENSER S/N 9

FREE-RUN TEST ON PUMP MOTOR WITH GEARBOX: 11,300 RPM @ ARMATURE (20 VDC)

PUMP PERFORMANCE TEST

3 MINUTE RUN:

	VOLTS	PRESS.	FLOW	FLOW
START	20 VDC	85 PSIG	53 %	7.5 GPM
FINISH	15 VDC	85 PSIG	30 %	

(RUN USING 15 A. CHARGER AS WELL AS 13 BATTERY FROM UNIT)

ENDURANCE RUN @ 95 PSIG INITIAL SETTING

TIME (SEC)	VOLTS	PRESS. PSIG	FLOW %	FLOW GPM, APPROX.	
0	23	95	56	8.2	(FLOWMETER
30	22	92	55	8.0	NOT
60	21.7	88	55	8.0	CALIBRATED)
90	20.7	86	55	8.0	
120	19.5	82	53	7.8	
150	18	75	51	7.5	
180	17.5	70	49	7.25	
210					

RELIEF VALVE PRESSURE 120 PSIG
RECHECK 130 PSIG
NOTE: DEPENDS ON BATTERY VOLTAGE

TEST OF ASSEMBLED UNIT (COMPLETELY FULL, WATER)

INITIAL DISCHARGE:	60 SEC. - BATTERY	13 VDC
	208 SEC. @ 20 VDC	
REFILL (FULL):	190 SEC. @ 20 VDC	
DISCHARGE:	252 SEC. @ 20 VDC	

NOTE: DISCHARGE PRESSURE WAS NOT MEASURED, NOZZLE SHOULD BE SIZED FOR 75 PSIG.

Pages _____
Page _____

Book _____ Page 1